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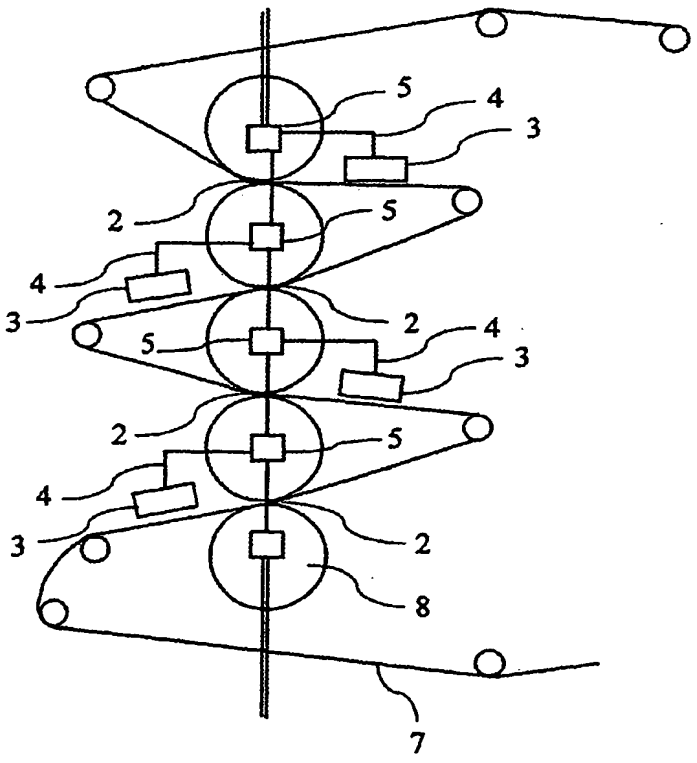

(57) Abstract: The invention relates to a method and an apparatus for the calendering of paper by an arrangement where the paper is passed via one or more nips (2) in a calender and the nip load, calendering temperature and/or moistening are adjusted by means of a regulator (5) provided in conjunction with the nip. According to the invention, the properties of the calendered paper are measured after a desired calender nip (2) and the nip load, calendering temperature and/or moistening in at least one, desired calender nip are adjusted on the basis of the measurement results so that a desired combination of paper properties is achieved in the final product.

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METHOD AND APPARATUS FOR CONTROLLING PAPER PROPERTIES IN A CALENDAR

The present invention relates to a method as defined in the preamble of claim 1 and to an apparatus as defined in the preamble of claim 11 for the calendering of paper.

In prior art, methods for the calendering of paper are known. Previously known are also systems for the control and regulation of calendering, e.g. from specifications US 5045342, US 5743177, US 4982334, US 4480537, US 4370923, US 4114528 and EP 0940501. As is known, calendering is regulated by controlling the nip load, calendering temperature and moistening.

Specification US 5045342 discloses a system for controlling the surface gloss of sheet material in connection with a calender, in which a sensor is used to measure the degree of surface gloss and the thickness of the sheet material at various points in the transverse direction of the sheet and, on the basis of the measurement results, the levels of temperature and moisture are adjusted independently of each other so as to achieve the desired properties.

Specification US 5743177 discloses a system for controlling paper thickness in the transverse direction of the calender, wherein properties of the paper web, such as thickness and density, are measured and e.g. the calender nip pressure is adjusted on the basis of the measurements. Specification US 4982334 discloses a system for controlling the calendering of sheet material wherein a given property of the sheet material is measured during the calendering of the sheet material and the measurement results are input into the control system of the calender. Specification US 4480537 discloses a method and a system for the calendering of web material wherein the thickness and surface properties of the web, such as gloss and smoothness, are measured and the temperature and

thickness are adjusted in a supercalender on the basis of the measurements. Specification US 4370923 discloses a calender for smoothing the surface of a paper strip wherein the smoothness of the paper surface is measured and the force and temperature of the rollers touching the paper are adjusted. Specification US 4114528 discloses a device for adjustment of the thickness of a web in connection with a calender. Specification EP 0940501 discloses a gloss control system for a supercalender, comprising a number of controllable compressed air jets.

In prior-art multi-nip calenders, the nip pressure is constant or increases as the paper advances in the operating direction.

A problem with prior-art methods and equipment is how to maintain a sufficiently high level of quality regarding the surface properties of the paper. Especially in on-line calendering, it has been necessary to increase the operating speed, nip pressure and calendering temperature in order to achieve a sufficient level of paper quality. The combination of high operating speed, high calendering temperature and high pressure weakens the polymer rollers of the calender so that they are easily damaged in long-time operation. In addition, a problem regarding e.g. on-line calendering is that, in certain calenders used today, the number of calender nips is too large; for reasons of runnability, the number of nips should be reduced.

The object of the present invention is to eliminate the above-mentioned drawbacks in connection with the calendering of paper. A specific object of the invention is to disclose a new and improved method and apparatus for the calendering of paper and for controlling the calendering process so that a desired paper quality level is achieved and maintained in all situations.

The method and apparatus of the invention are characterized by what is presented in the claims.

The invention is based on a method for calendering paper using an arrangement wherein the paper is passes through one or more nips in a calender and the nip load, calendering temperature and/or moistening are adjusted by means of a regulator in conjunction with the nip. According to the invention, the properties, e.g. gloss, thickness or moisture, of the calendered paper, i.e. paper having passed through the nip, are measured by means of at least one sensor after a desired calender nip and the measurement results are passed to the regulator, and the nip load, calendering temperature and/or moistening in at least one, desired calender nip are adjusted by means of a regulator on the basis of the measurement results so that a final product having the desired combination of paper properties is achieved.

According to the invention, the calendering is preferably controlled by measuring the paper properties substantially after each nip, after a few desired nips and/or from the final product after the last nip and adjusting the calendering, i.e. the calender nips, on the basis of the measurement results. The method of the invention can also be called a closed-loop system of regulation/control of a calender nip, wherein the nip load, temperature and/or moisture in each individual calender nip is adjusted on the basis of the measurement results so that an advantageous operating combination and an advantageous combination of properties of the final product are achieved.

In an embodiment of the invention, the properties of the calendered paper are measured substantially after each calender nip, using at least one sensor. If several sensors are used, then they may form an aggregate of measuring elements. In an embodiment, the properties of the calendered paper are meas-

ured after at least one, predetermined calender nip, e.g. after the last nip.

In an embodiment of the invention, the nip load, temperature and/or moisture of substantially each calender nip are adjusted on the basis of the measurement results.

In an embodiment of the invention, the calender nip is controlled on the basis of the measurement results for the same nip. In an embodiment, the calender nip is controlled on the basis of the measurement results obtained from the final product. In an alternative embodiment, the calender nip is controlled on the basis of both the measurement results for the nip in question and those for the final product.

In an embodiment of the invention, the nip load and calendering temperature of the calender nip are adjusted substantially simultaneously.

In an embodiment of the invention, nip load, calendering temperature and moistening of the calender nip are adjusted substantially simultaneously.

In an embodiment of the invention, each calender nip is controlled by means of a separate regulator, allowing the paper properties to be adjusted on a nip-specific basis. In an embodiment of the invention, the regulator is so placed that it is arranged to control at least two calender nips.

In an embodiment, each calender nip is provided with at least one controlling element for passing the measurement results from the sensor to the regulator, said controlling element being placed in conjunction with the calender nip, preferably after it. In a preferred embodiment, the number of controlling elements is equal to the number of calender nips. In an embodiment, the number of controlling elements is equal to the number of regulators. In an embodiment, the measurement results are input from the sensor to a nip-specific controlling element, which

passes them on to a nip-specific regulator. In an alternative embodiment, only one controlling element is provided.

In an embodiment, a calender nip group is formed for the calendering of paper. For the calender nip group, preferably a common regulator is provided. The calender nips in the calender can be divided in the top-to-bottom direction into zones, in each of which the temperature, nip load and/or moisture can be adjusted separately. For each nip group a common regulator may be provided, or alternatively a separate regulator may be provided for each nip. Alternatively, the load, temperature and moisture in each calender nip can be adjusted on a nip-specific basis in the case of a nip group.

In an embodiment, a nip unit is formed which contains one separate nip substantially independent of the other calender nips. In this case, each nip of the calender together with its regulation elements is preferably a separate unit. In an embodiment, a calendering aggregate comprising one or more separate nip units is formed.

In a preferred embodiment, the calendering can be regulated with a desired combination of control quantities (e.g. load, temperature and/or moistening) by simultaneously adjusting desired calender nips to improve certain paper properties in the final product.

The apparatus of the invention, i.e. calender, comprises one or more nips through which the paper has been arranged to pass, and a regulator for the adjustment of nip load, calendering temperature and/or moistening in connection with the nip. According to the invention, the apparatus comprises at least one sensor for measuring the properties of calendered paper after a desired calender nip and at least one controlling element for passing the measurement results to a regulator, by means of which the nip load, calen-

dering temperature and/or moisture of at least one, desired calender nip are controlled on the basis of the measurement results so that a desired combination of paper properties is achieved in the final product.

By using the so-called closed-loop method and apparatus of the invention, it is possible to improve the controllability of calendering. The method and apparatus of the invention make it possible to produce paper of improved quality in respect of e.g. gloss, thickness and/or moisture, and the paper properties can be easily monitored and corrected during the calendering process.

As compared with prior art, the invention provides the advantages of better manageability and variability as well as nip-specific controllability of temperature, pressure (nip load), moisture and processing time during the calendering process so that desired and advantageous paper properties are achieved without the calender rollers being damaged due to an excessively high temperature-pressure-operating speed combination. The invention makes it possible to simultaneously adjust desired control quantities for desired nips, e.g. three or five nips, or nip groups during the calendering process, or alternatively to control each nip separately, in order to improve certain properties in the final product. At the same time, the production efficiency of the calender can be improved.

The invention provides the advantage that a higher average temperature than at present can be utilized in the calender, because it is possible to temporarily use temperatures higher than average in connection with the rollers without damaging the rollers. The one or more nips held at a higher temperature and the nip loads are changed regularly. The nip load is controlled on the basis of information obtained from the sensors measuring the paper properties. Thus,

it is possible to achieve e.g. a better production efficiency, i.e. operating speed, or a higher degree of gloss of the paper. Similarly, the nip load can be temporarily raised to a level higher than normal in the calender.

The control system according to the invention allows different nips to be alternately charged e.g. with a high load or temperature, at the same time distributing the total load more evenly between different nips as a function of time, thereby extending the interval between roller surface renewals. Further, the invention allows the calendering temperature to be maximized in relation to the nip load used.

Moreover, the invention can be used to improve the performance of the prior-art multi-nip calender. The invention makes it possible to reduce the number of nips in the calender and yet to achieve the desired paper quality, which is an advantage e.g. in respect of runnability of an on-line calender.

A further advantage provided by the nip unit embodiment of the invention is an improvement of the efficiency and control of the calendering and a maximally advantageous combination of final properties of the product. With this embodiment, a desired combination of variables can be applied to the paper at different stages of the calendering process.

The apparatus of the invention has the advantages of simplicity and ease of implementation.

The method and apparatus of the invention can be applied to advantage both in multi-nip calenders and in so-called single-nip calenders. In addition, the method of the invention can be applied/utilized in prior-art and existing calenders after only slight modifications of equipment.

In the following, the invention will be described in detail by the aid of examples of its em-

bodiments with reference to the attached drawings, wherein

Fig. 1 - 3 present diagrams representing certain embodiments of the apparatus of the invention.

According to the invention, the calendering is controlled so as to achieve desired and advantageous final paper properties, by monitoring, i.e. measuring the property or properties of the paper, e.g. gloss, thickness and moisture, after desired calender nips, and adjusting the nip load, calendering temperature and moistening in connection with desired nips on the basis of the measurement results.

Fig. 1 presents an embodiment of the apparatus of the invention for the calendering of paper, i.e. a multi-nip calender. The calender 1 in itself is fully known in prior art, and it will not be described here in detail. The calender in Fig. 1 preferably comprises several, in this embodiment five rolls 8 and four calender nips 2, through which the paper web 7 has been arranged to pass during calendering. Further, the calender comprises four sensors 3 disposed after the nips 2 to measure the properties, such as paper gloss, thickness and moisture, of the calendered paper after each nip. The sensor 3 may be any type of measuring device known in the art. One sensor can be used to measure either one paper property or alternatively several paper properties as in the embodiment in presented Fig. 1. If the sensor can only measure one property and there are more properties to be measured, then it is possible to use either several separate sensors or a known measuring apparatus comprising several sensors.

The calender 1 in Fig. 1 further comprises four controlling elements 4 and four regulators 5 for controlling and regulating the calendering process. Each controlling element 4 is connected to a corresponding sensor 3, and each regulator is connected to

a corresponding controlling element 4. In addition, the regulator is connected to a calender nip 2 and to the rolls 8 on either side of the nip, and it has been arranged to function so that it adjusts the calender nip 2 and/or the rolls 8 in a desired manner. The controlling elements and regulators used may be any controlling elements and/or regulators known in the art, and they will not be described here in detail.

The embodiment presented in Fig. 1 has one sensor 3, one controlling element 4 and one regulator 5 for each calender nip 2. The sensor 3 and the controlling element 4 are disposed after the nip, while the regulator 5 is placed in conjunction with the nip. The controlling elements 4 are connected to each other so that the measurement results from the sensors 3 are available to all regulators 5, so that each nip 2 can be controlled in a desired manner on the basis of either nip-specific measurement results and/or the measurement results for the final product.

In the embodiment of the apparatus in Fig. 1, a paper web 7 is passed through the nips 2 of a multi-nip calender in a top-to-bottom direction, and desired paper properties are measured by means of a sensor 3 after each nip 2. The measurement results are taken by the controlling element 4 from the sensor 3 to the regulators 5, and the nip load, calendering temperature and moistening affecting the paper passing through each nip is adjusted by means of the regulator. By monitoring the paper quality, the regulation of the calender nip can be directed towards the achievement of paper having the desired properties. The quantities controlling the regulation of the calender nip are in this case gloss, thickness and moisture of the paper.

Fig. 2 presents an embodiment of the apparatus of the invention, a so-called single-nip calender for the calendering of paper. In this embodiment, the

calender 1 comprises three separate nips 2 independent of each other, which are designated as nip units 6. A nip unit 6 thus comprises two rolls 8 and a calender nip 2 between them. The calender assembly consists of nip units 6, in this case three nip units. In other respects, the embodiment of the apparatus presented in Fig. 2 corresponds to that in Fig. 1, in other words, after each nip 2 there is a sensor 3 for the measurement of paper properties and a controlling element 4 for passing the measurement results to the regulator 5. The regulator is placed in conjunction with the nip and it serves to regulate the load, temperature and moisture in the calender nip.

Fig. 3 presents a multi-nip calender according to the invention, comprising a nip group. In this embodiment, the nip group comprises four calender nips 2 and one regulator 5, which has been arranged to control all four nips 2 either in batch or on a nip-specific basis, adjusting each nip 2 separately. The nip group further comprises four sensors 3 and controlling elements 4, one of each being placed after each nip 2. In an alternative embodiment, each nip group may have only one controlling element 4, in which case the controlling element is arranged to pass the measurement results after each nip 2 from the sensor 3 to the regulator 5. The calender 1 may also comprise more than one nip group.

The method of the invention for the calendering of paper can be utilized in both traditional calendering and in so-called single-nip calendering, where the paper is passed through one or more separate nips. In an alternative embodiment, the calendering is controlled by regulating the relation of roll temperature to nip pressure, which makes it possible to monitor the temperature and pressure load on the rolls and to shift it in a desired manner to avoid damage to the rolls. In another embodiment, the calendering can be

controlled by regulating the calendering effect on the paper, e.g. by applying the effect via temperature mainly to the surface of the paper, e.g. gloss, or via nip pressure to the bulk of the paper, e.g. roughness.

The method and apparatus of the invention are applicable as different embodiments for the manufacture of different paper sorts by calendering. Furthermore, the method and apparatus of the invention are applicable for controlling the calendering process so as to achieve a product having the desired properties.

The embodiments of the invention are not limited to the examples described above; instead, they may be varied within the scope of the following claims.

CLAIMS

1. Method for the calendering of paper by an arrangement where the paper is passed via one or more nips in a calender and the nip load, calendering temperature and/or moistening are adjusted by means of a regulator provided in conjunction with the nip, characterized in that the properties of the calendered paper are measured after a desired calender nip and the nip load, calendering temperature and/or moistening in at least one, desired calender nip are adjusted on the basis of the measurement results so that a desired combination of paper properties is achieved in the final product.

2. Method as defined in claim 1, characterized in that the properties of the calendered paper are measured substantially after each calender nip.

3. Method as defined in claim 1 or 2, characterized in that the properties of the calendered paper are measured after at least one, predetermined calender nip.

4. Method as defined in any one of claims 1 - 3, characterized in that the nip load, temperature and/or moisture in substantially each calender nip are adjusted on the basis of the measurement results.

5. Method as defined in any one of claims 1 - 4, characterized in that the calender nip is controlled on the basis of the measurement results for the same nip.

6. Method as defined in any one of claims 1 - 5, characterized in that the calender nip is controlled on the basis of the measurement results obtained from the final product.

7. Method as defined in any one of claims 1 - 6, characterized in that the nip load and

calendering temperature of the calender nip are adjusted substantially simultaneously.

8. Method as defined in any one of claims 1 - 7, characterized in that the nip load, calendering temperature and moistening in the calender nip are adjusted substantially simultaneously.

9. Method as defined in any one of claims 1 - 8, characterized in that each calender nip is controlled by means of a separate regulator.

10. Method as defined in any one of claims 1 - 9, characterized in that at least two calender nips are controlled by means of one regulator.

11. Apparatus for the calendering of paper, said apparatus comprising one or more calender nips (2) and a regulator (5) for controlling the nip load, calendering temperature and/or moistening in connection with the nip (2), characterized in that the apparatus comprises at least one sensor (3) for measuring the properties of the calendered paper after a desired calender nip (2) and at least one controlling element (4) for passing the measurement results to the regulator (5), by means of which the nip load, calendering temperature and/or moistening in at least one, desired calender nip (2) are adjusted on the basis of the measurement results so that a desired combination of paper properties is achieved in the final product.

12. Apparatus as defined in claim 11, characterized in that at least one sensor (3) is placed substantially after each calender nip (2) to measure the paper properties.

13. Apparatus as defined in claim 11 or 12, characterized in that at least one sensor (3) is placed after the last calender nip (2) to measure the properties of the final product.

14. Apparatus as defined in any one of claims 11 - 13, characterized in that at least one

controlling element (4) is placed after each calender nip (2).

15. Apparatus as defined in any one of claims 11 - 14, characterized in that the controlling element (4) is so disposed that it is arranged to pass the measurement results after at least two calender nips (2) to the regulator (5).

16. Apparatus as defined in any one of claims 11 - 15, characterized in that at least one regulator (5) has been arranged to control the nip load, calendering temperature and/or moistening substantially in each calender nip (2) on the basis of the measurement results.

17. Apparatus as defined in any one of claims 11 - 16, characterized in that a regulator (5) is placed in conjunction with each calender nip (2).

18. Apparatus as defined in any one of claims 11 - 17, characterized in that the regulator (5) has been arranged to control at least two calender nips (2).

19. Apparatus as defined in any one of claims 11 - 18, characterized in that the apparatus comprises a calender nip group, which is controlled substantially simultaneously.

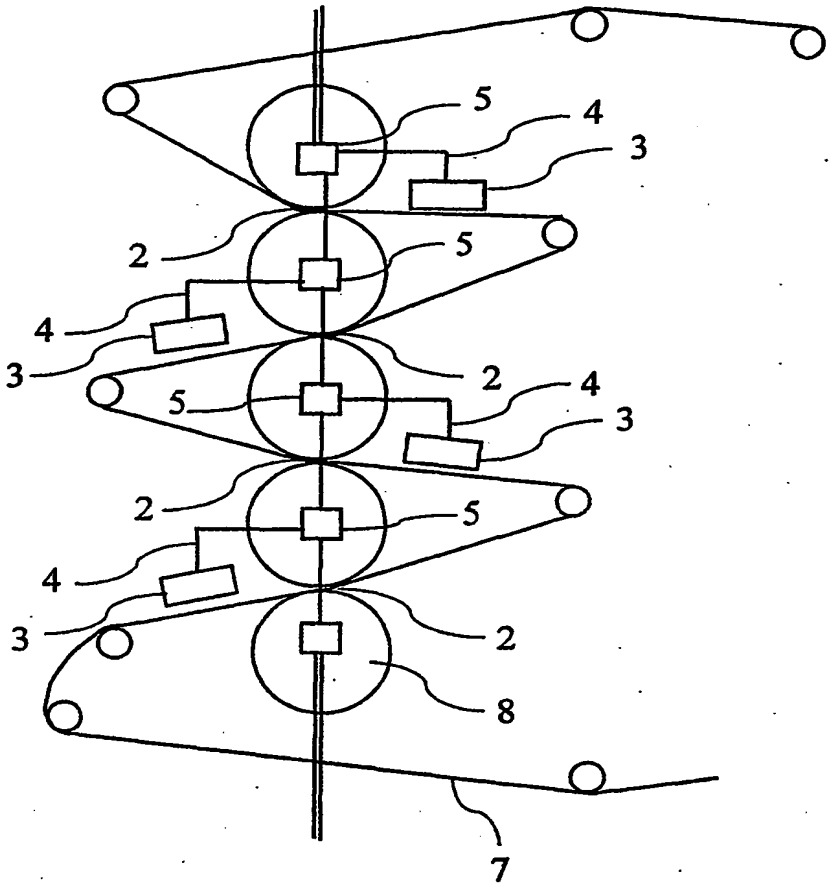

Fig. 1

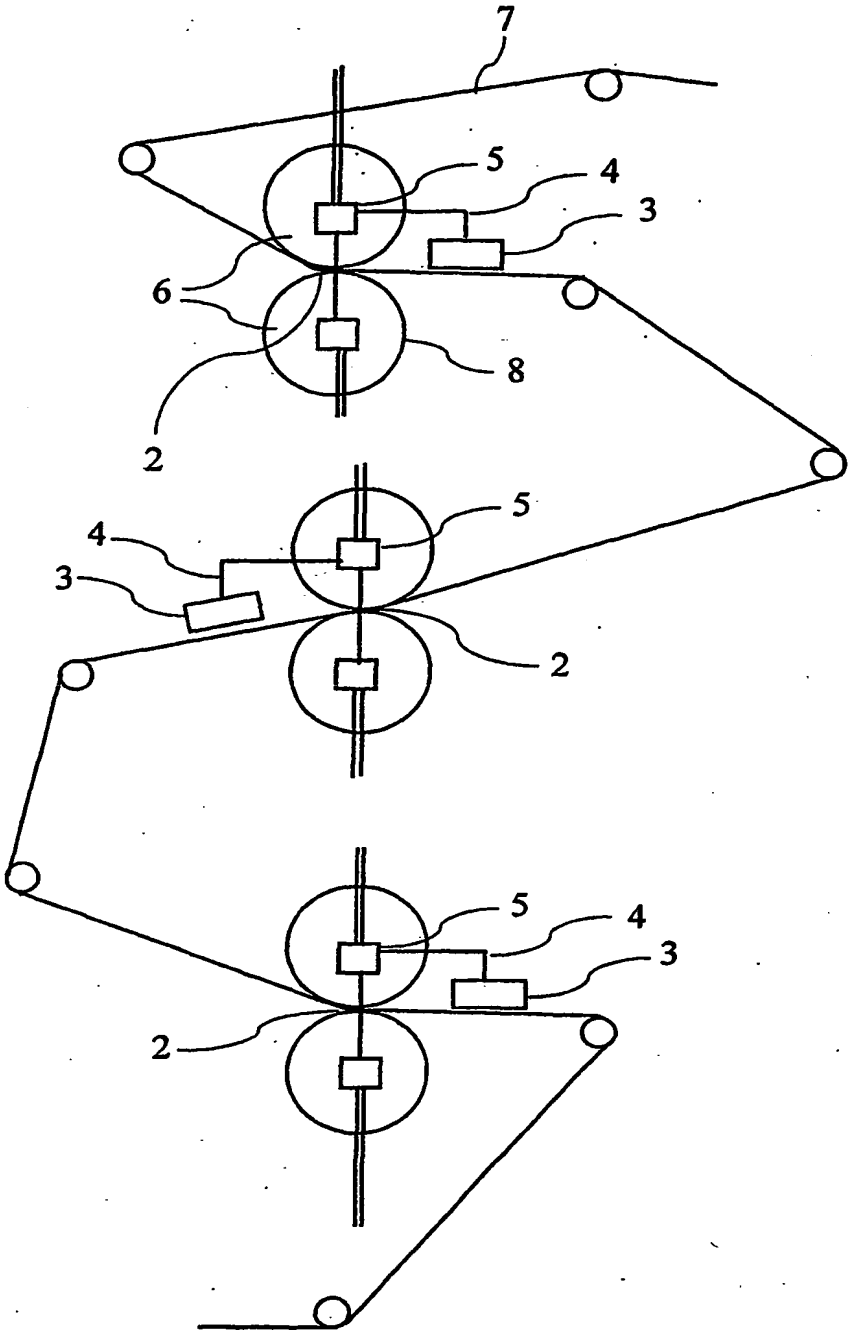

Fig. 2

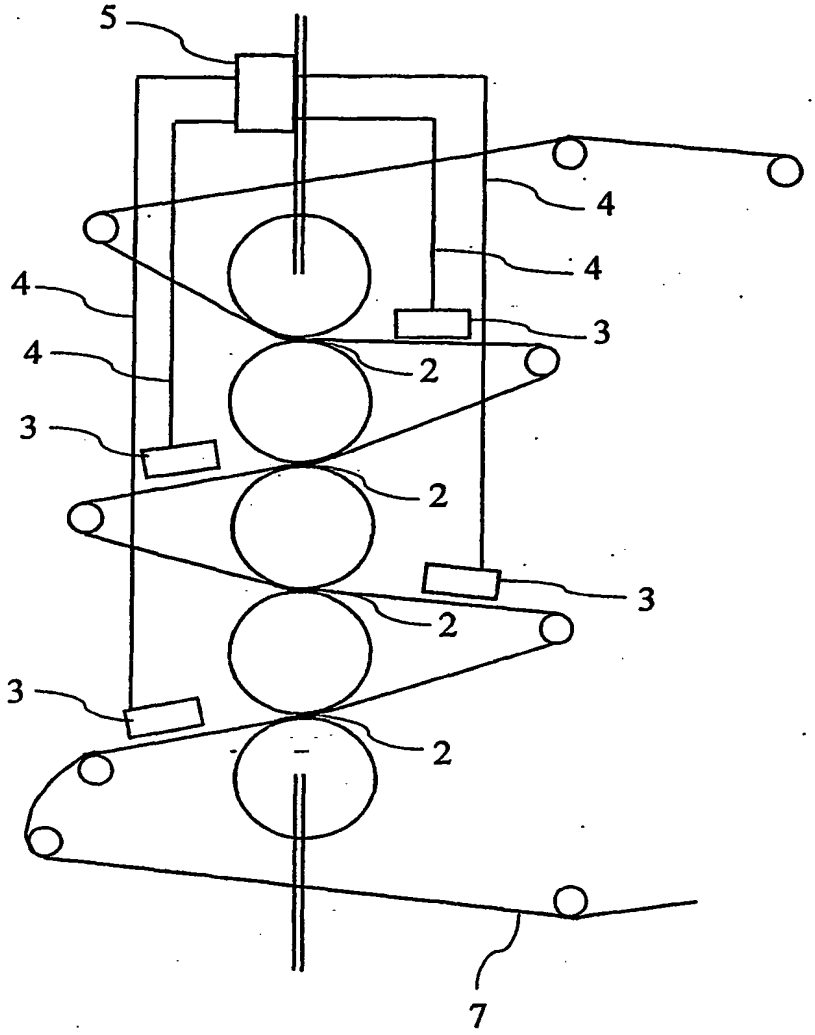

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/01106

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D21G 1/00, D21G 9/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4370923 A (SYLVIA SCHMIDT), 1 February 1983 (01.02.83), column 4, line 26 - column 5, line 6, figures 1,2, claim 1	1,3,5-8, 10-11,13,15, 18-19
Y	--	2,4,9,12,14, 16-17
Y	US 5033373 A (BERNHARD BRENDEL ET AL), 23 July 1991 (23.07.91), column 4, line 39 - column 5, line 5, figure 1	2,4,9,12,14, 16-17
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2002	20 -03- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Nina Bergström/ELY Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT
Information on patent family members

28/01/02

International application No.
PCT/FI 01/01106

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4370923 A	01/02/83	DE 2823738 A,C	13/12/79
		FI 63981 B,C	31/05/83
		FI 791427 A	01/12/79
		GB 2022163 A	12/12/79
		JP 55090694 A	09/07/80
US 5033373 A	23/07/91	BR 8902056 A	05/12/89
		DE 3815463 A,C	16/11/89
		EP 0341457 A	15/11/89
		FI 892162 A	07/11/89
		JP 1321999 A	27/12/89